MPIfR / BKG Correlator

status report

8.2.2010

MK IV hardware correlator

- Installed 12/1999
  - Joint MPIfR – BKG project
  - Support by IGG Bonn University
- 7 Mark 5A (+ 1 Mark 5A for e-VLBI transfer)
- 4 Mark 5B
- Geodetic usage ~ 60%
- Astronomy:
  - mm-VLBI (GMVA) and 1 mm-VLBI
  - MPIfR-based projects
  - Pulsar VLBI, astrometry

Geodetic usage (2009)

- 49 INT 3
- 51 R1
- 3 T2
- 6 OHIG

E-VLBI: Uses UDP-based Tsunami protocol from:

- Tsukuba, Ny-Ålesund, Onsala, Metsähovi, Wettzell, Kashima (including data of the antarctic Syowa station), Aira and Chichijima
- Mizusawa and Ishigakijima (once)

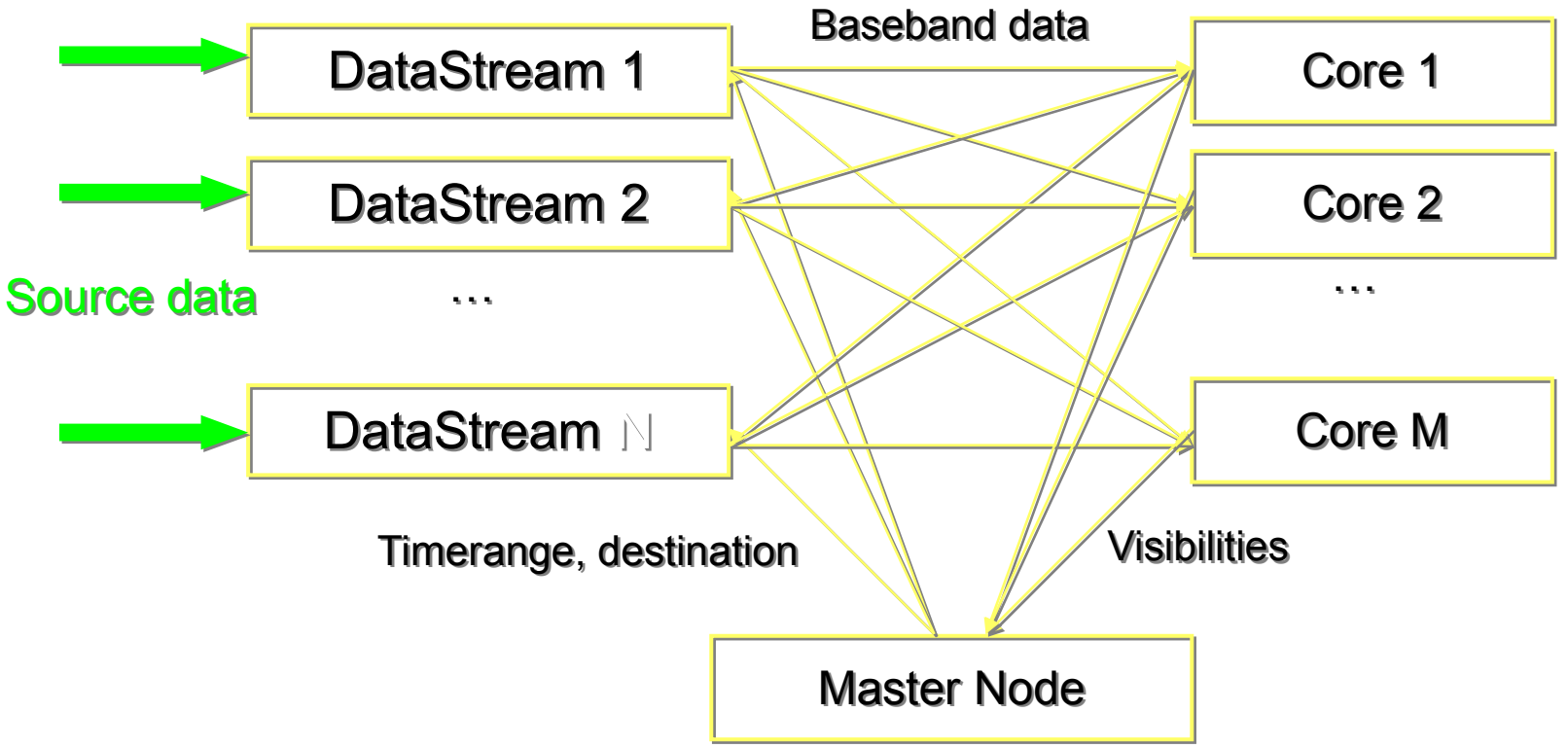
Software-Correlator

- A software correlator is a program which is executed on a computer or computer cluster
- Software is not clocked: slower or faster than real-time
- No limits on integration time or # of channels
- Floating point vs. integer calculations
- Can easily be modified
- Short development time
- More computers = more performance
- Higher energy consumption than FPGA or hardware correlator

DiFX software correlator

- Developed by Adam Deller, Swinburne (NRAO)
- Now developed by „Consortium“
  NRAO, MPIfR, MRO, INAF, ATNF, Curtin, ...
- FFT with cross-multiplication (FX)
- C++, IPP, Perl
- Reads data from Mark 5, files, e-VLBI, ...
- Output: FITS
- Message Passing Interface for cluster

The DiFX architecture



- MPI is used for inter-process communications
- DataStream: split data in ~msec time chunks and distribute to Cores
- Core: compute cross-spectrum, average, send to Master for averaging

Cluster:
60 Nodes w.
480 Cores
~4 TFlops

2x 20 TB

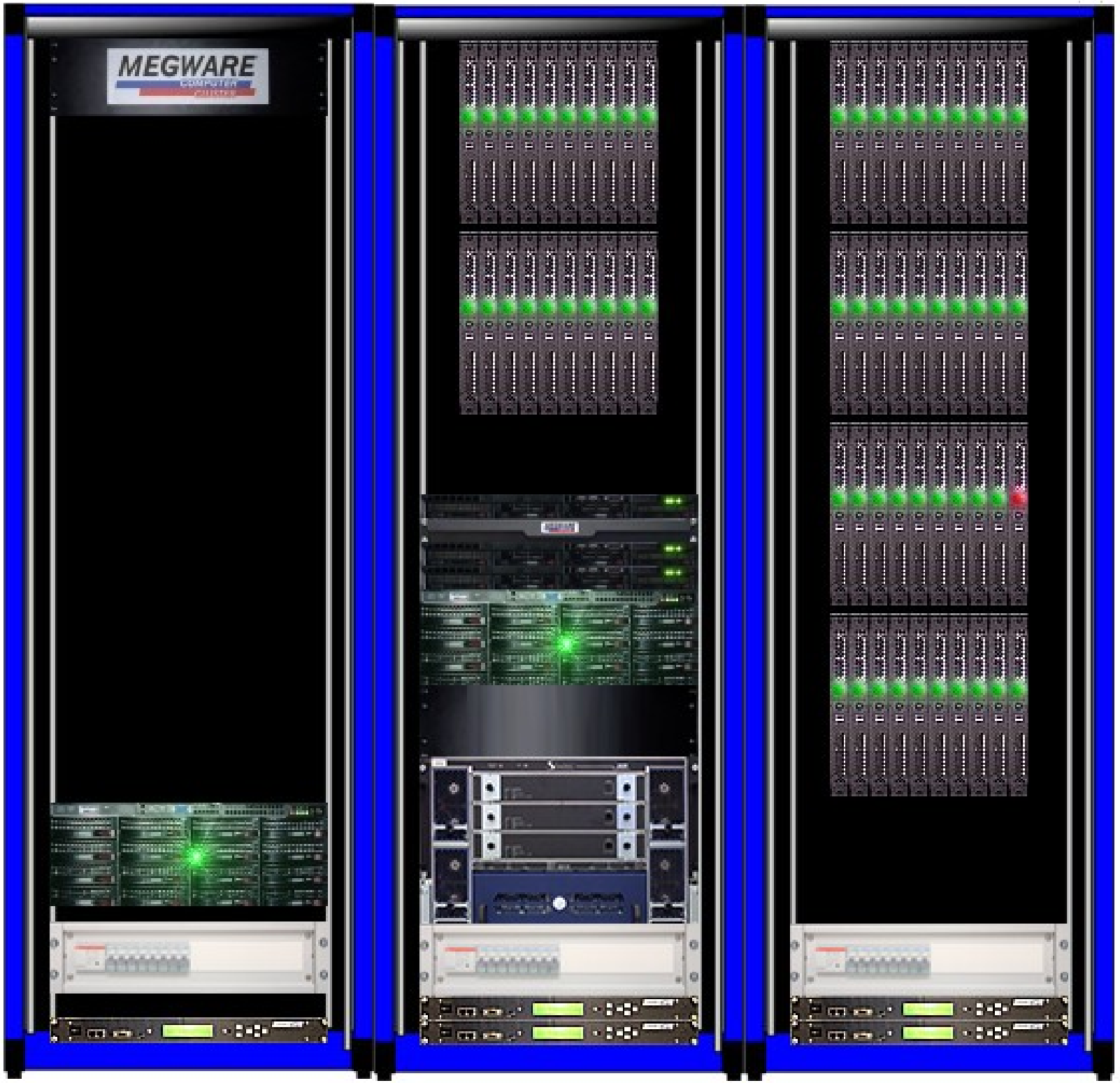
Infiniband
20 Gbit

2x 1 GE

FXmanager
Frontend
Appliance

Closed rack
cooling

20 TB for
geodesy
soon



Bonn Installation

- 13 Mark 5 units
  - 7 × 5A, 4 × 5B, 2 × 5C .... 2 more in Lab
- Source code from SVN repository
  - Version 1.5.2
- But: using FUSE and NFS to access 8-packs
  - Problems solved: stability, throughput
- Next: Installation of 32-bit DiFX – also on MK 5s
  - Cluster is 64-bit Linux, MK 5 is 32-bit (closer to NRAO version)
  - Alternative: 64-bit Mark 5 (SDK9, coming soon...)
- Local data-base for Experiments, 8-packs, Logs, messages...

Astronomical DiFX correlation

Already done or in progress:

- 96 phase centres on the sky in a 10 station VLBA Exp correlated in 1 Pass (~ double correlation time)
- 15 station EVN/global project @ 7 mm
- 3 station observation with 2 ms integration
- 5 days 12 stations 3 mm GMVA
  - 600 – 700 Mbit/s due to NFS over 1 G Ethernet

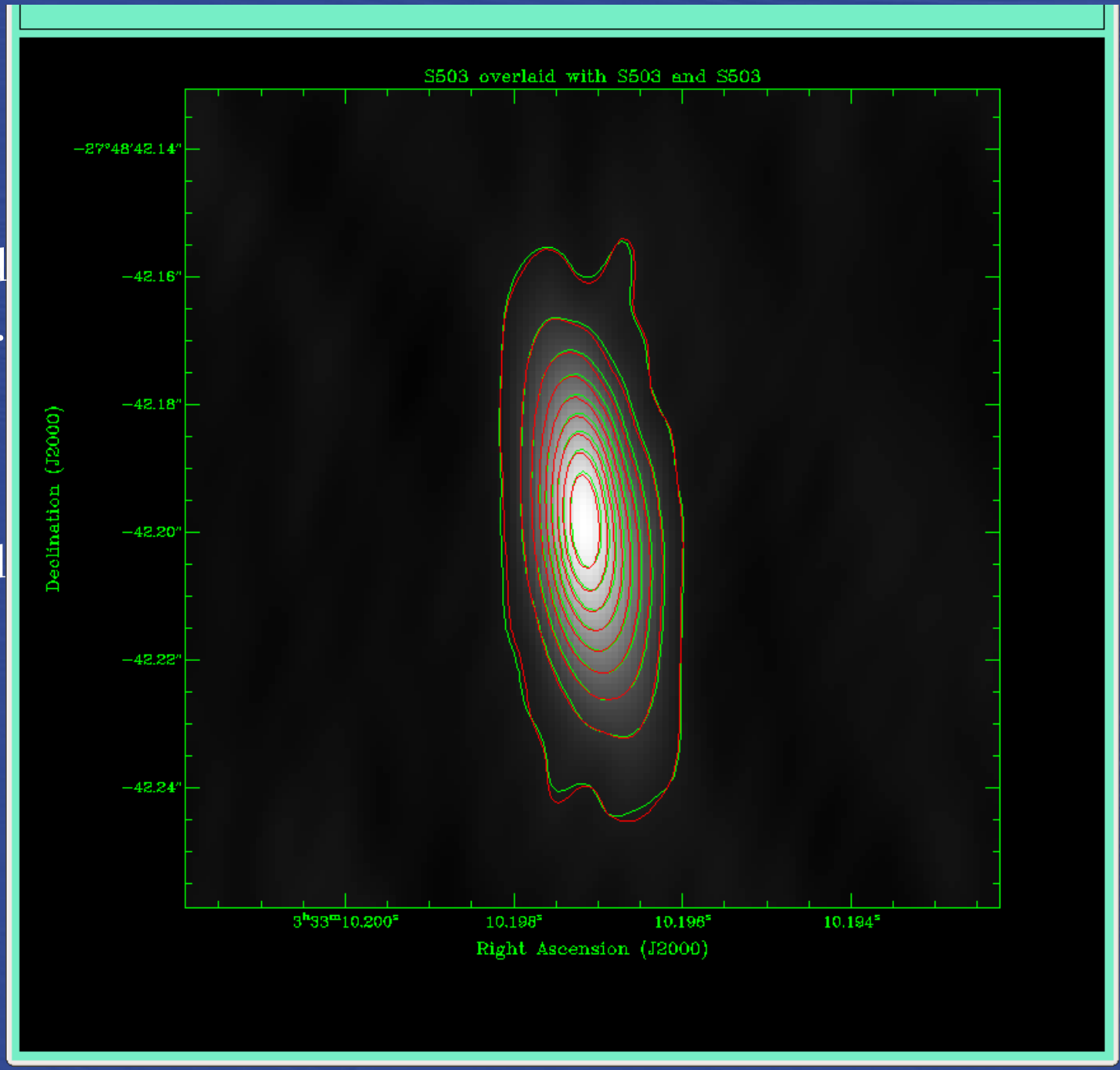
Waiting:

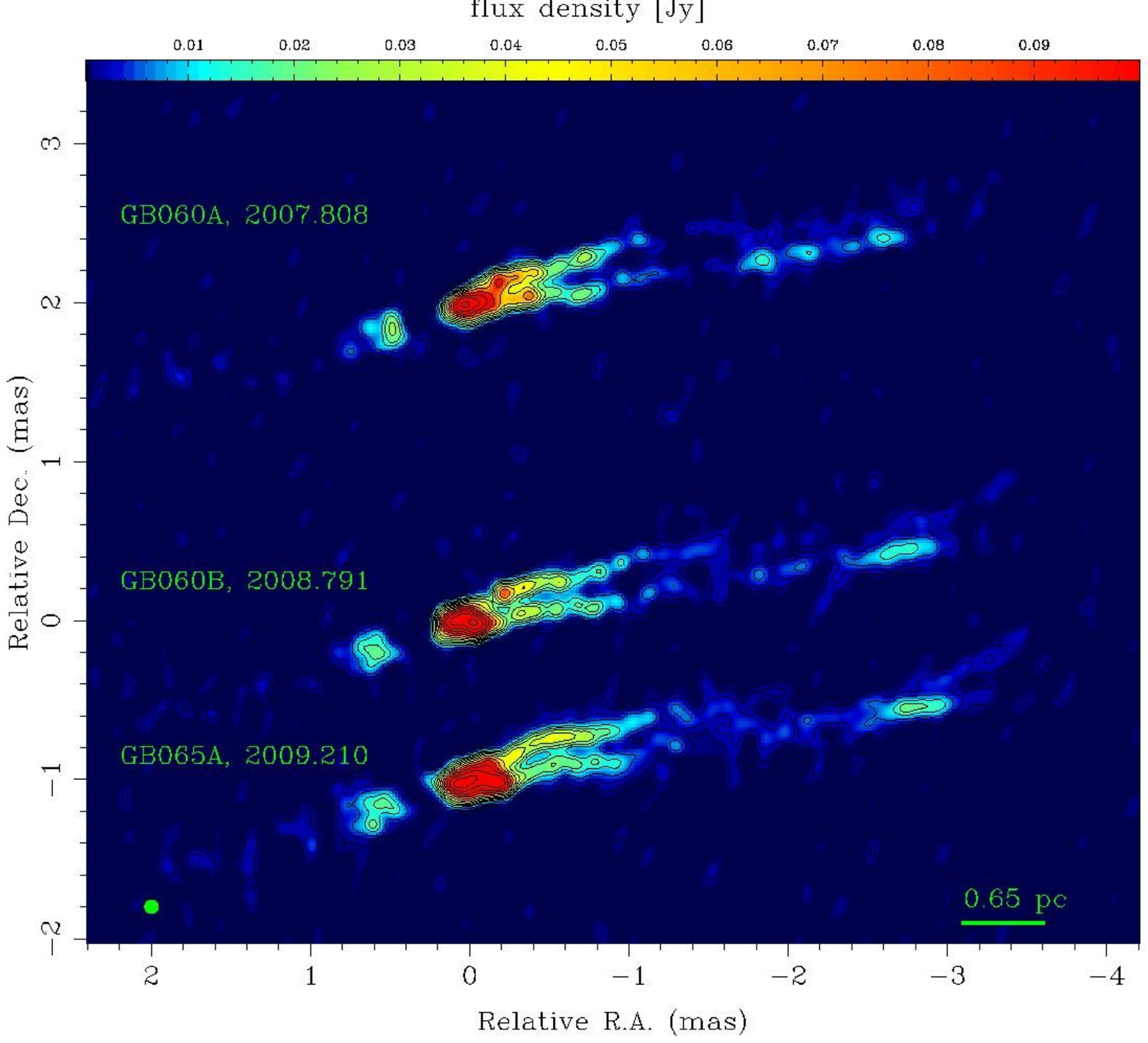
- 3 EVN observations with up to 16 stations
- Pulsar projects

Two maps are overlaid:

One correlation on source, one wide field correlation off source.

Green contours indicate the image made from the shifted data, and red contours indicate the image made from unshifted data.




flux density [Jy]
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
GB060A, 2007.808
GB060B, 2008.791
GB065A, 2009.210
0.65 pc
Relative Dec. (mas)
Relative R.A. (mas)
3
2
1
0
−1
−2
2
1
0
−1
−2
−3
−4

Phase cal. tone extraction in DiFX

- Coded by Frederic Jaron (MPIfR), Jan Wagner (Metsahovi), John Morgan (MPIfR) and Adam Deller (NRAO)
- Input from Walter Alef (MPIfR), Walter Brisken (NRAO) and Sergei Pogrebenko (JIVE)

- Default is to extract **all** phase cal. tones within the recorded band.
- Accumulation period is the same as the accumulation period of the visibilities (for now)

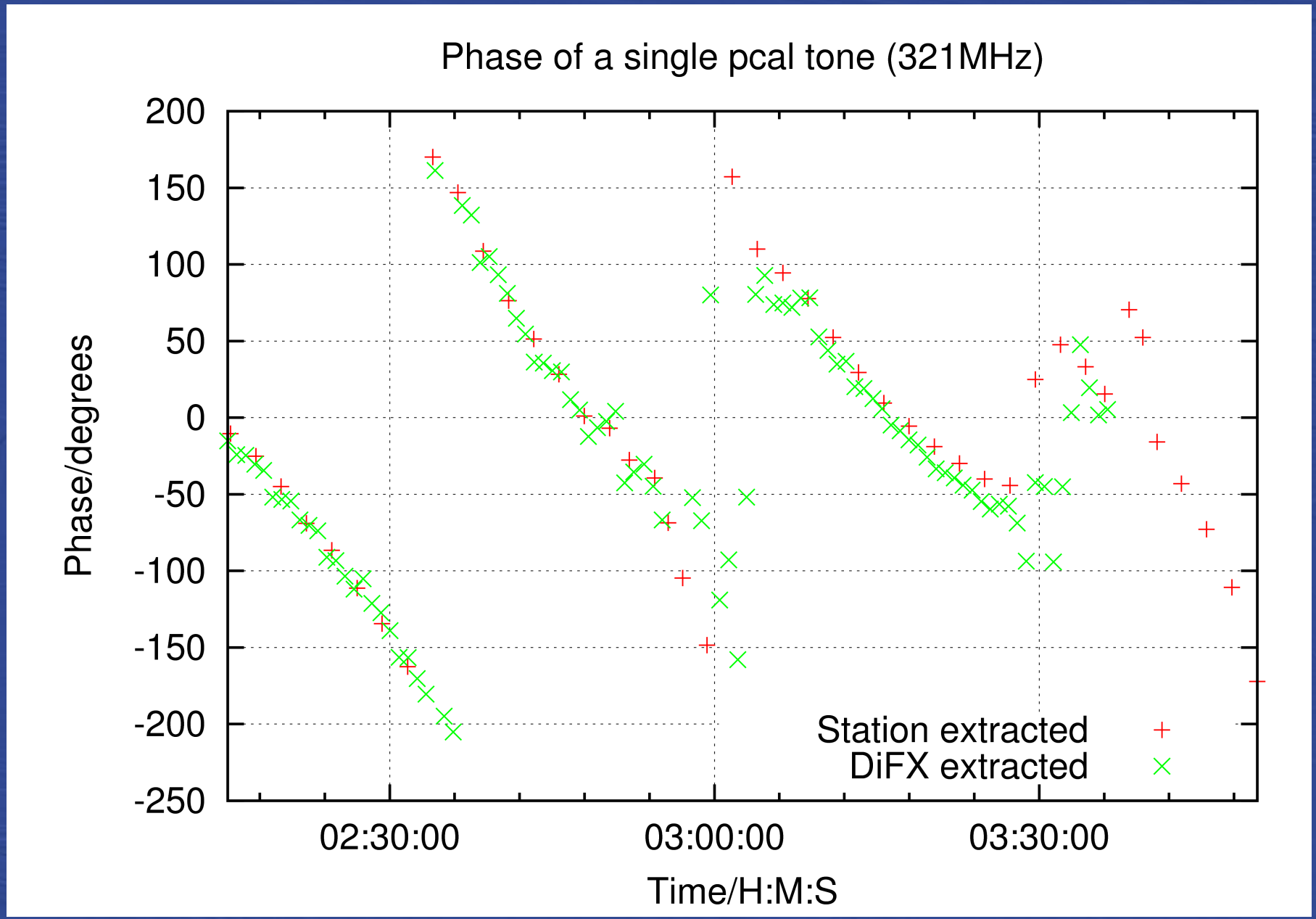
Implementation

Distributed nature of DiFX means that we can only work with small time-intervals of data

- In DiFX:
  - Broadband data is unpacked into floats one FFT block at a time (~1000 samples)
  - ~10^4 FFT blocks are copied into each accumulator one at a time (~100 milliseconds of data in total)
  - All phase cal tones are then extracted for this small block of data
  - Results are then averaged over the accumulation period (~1s) and written to disk (plain ascii file)

Progress

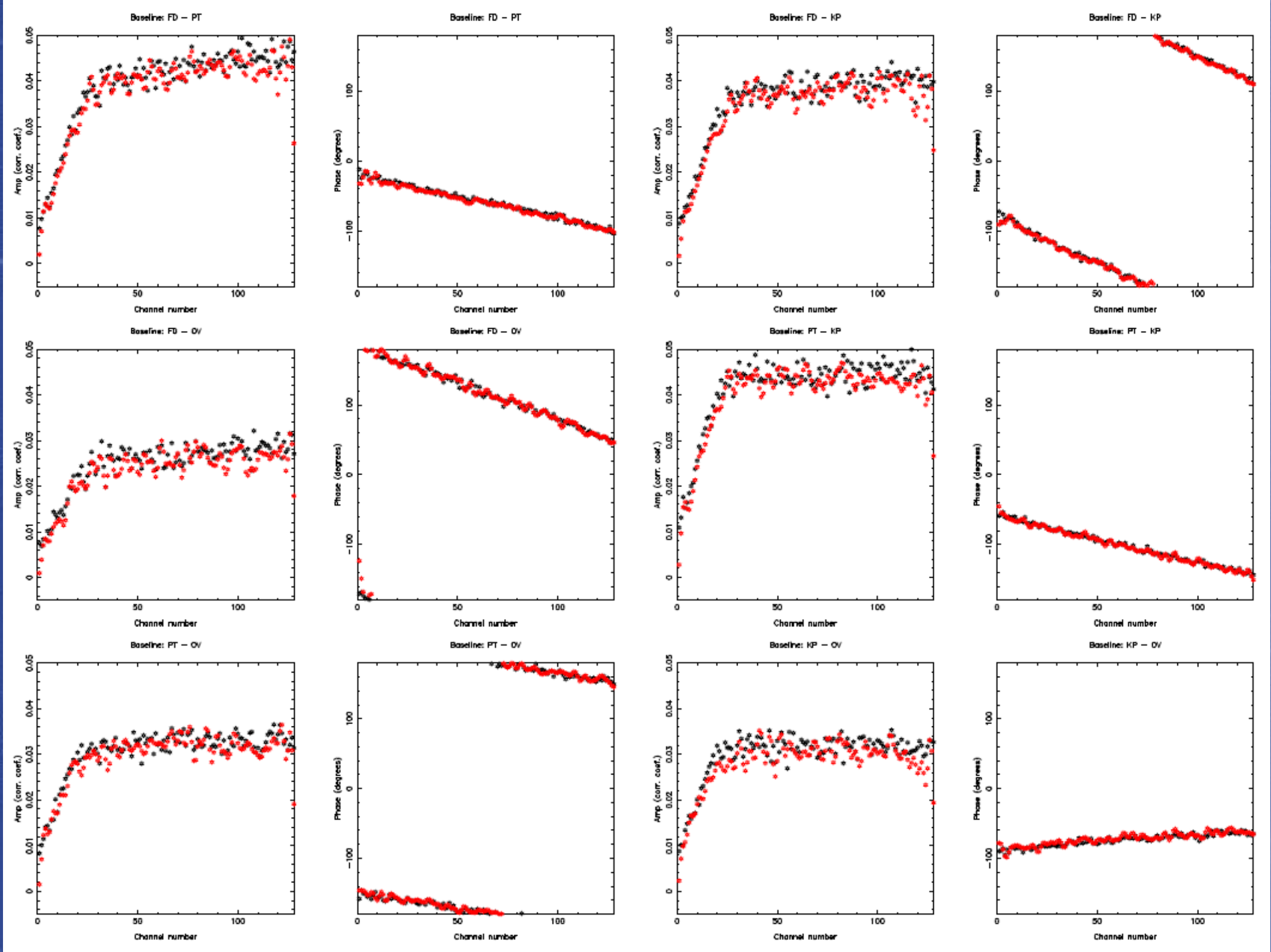
- Code available for inspection to anyone with access to the DiFX SVN archive
  - Produces correct pulse-cal phases since few days ago
- We hope to have a beta version in the next few weeks
  - Initially ASCII pulse-cal file for AIPS/PCLOD
  - Path into FITS-IDI (and AIPS) will be available later
  - Anyone with a DiFX installation is welcome to test it
- Will be available in DiFX 2.0

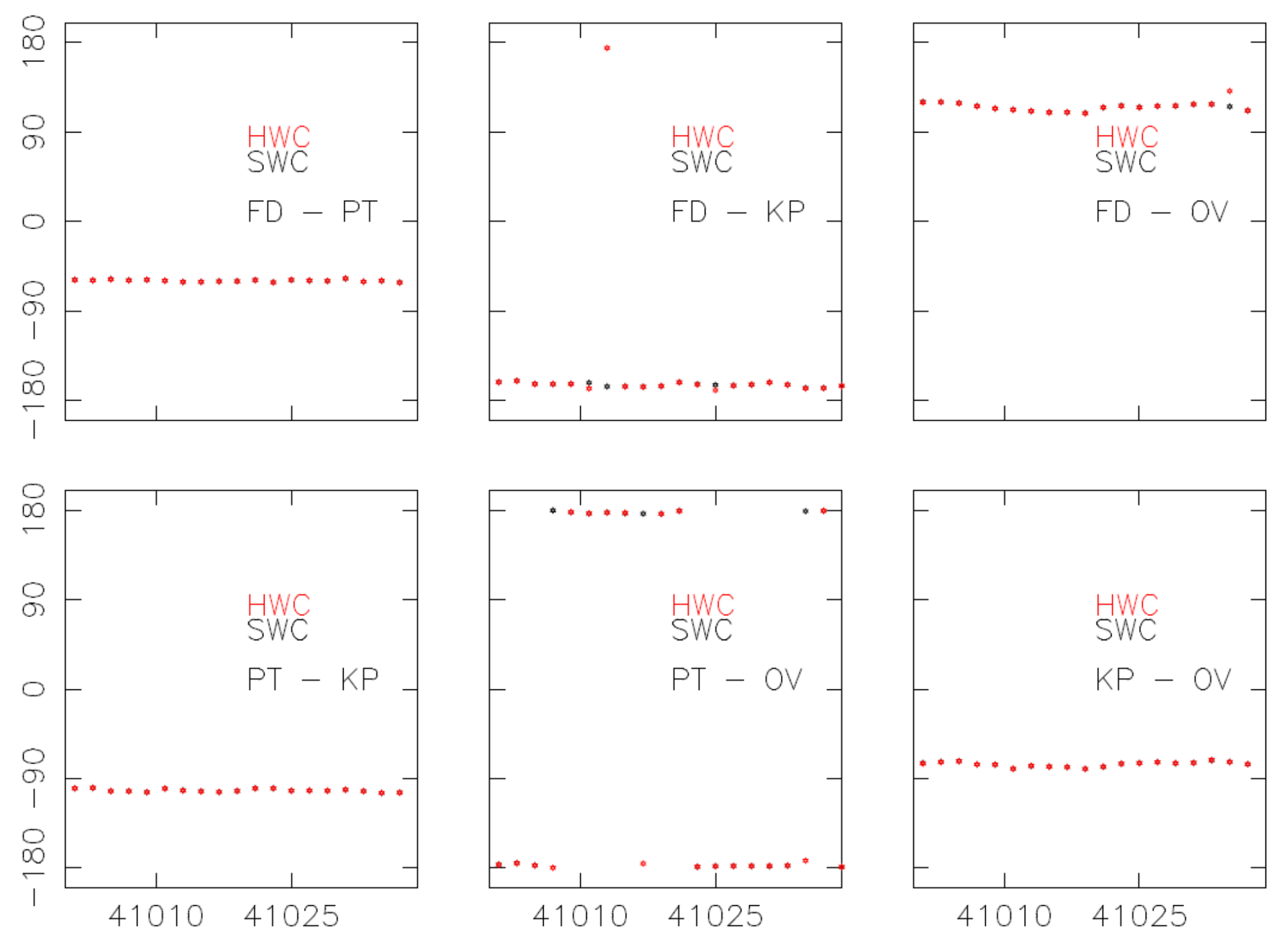

Phase of a single pcal tone (321MHz)
Phase/degrees
200
150
100
50
0
-50
-100
-150
-200
-250
02:30:00
03:00:00
03:30:00
Time/H:M:S
Station extracted
DiFX extracted

Geodetic Verification

- Comparison with the MK IV correlator in Bonn
  1. Published in Journal of Geodesy (Tingay et al.)
- Next comparisons (after implementation of phase-cal):
  1. EVN observation at 22 GHz (Petrov et al.)
  2. R1
     - May require: Interface DiFX to MK IV format
       Roger Capallo is leading this effort
  3. More observations ...

Switch over geodetic observations to DiFX in 2010


Baseline: FD – PT
Amp (corr. coef.)
Phase (degrees)
Channel number
Baseline: FD – KP
Baseline: FD – OV
Baseline: PT – KP
Baseline: PT – OV
Baseline: KP – OV


180
90
0
−90
−180
HWC
SWC
FD – PT
FD – KP
FD – OV
PT – KP
PT – OV
KP – OV
41010
41025